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Special Analysis for the Disposal of the Neutron Products Incorporated Sealed Source Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada

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1.0 Introduction

The purpose of this special analysis (SA) is to determine if the Neutron Products Incorporated (NPI) Sealed Sources waste stream (DRTK000000056, Revision 0) is suitable for disposal by shallow land burial (SLB) at the Area 5 Radioactive Waste Management Site (RWMS). The NPI Sealed Sources waste stream consists of 850 ^{60}Co sealed sources (Duratek [DRTK] 2013). The NPI Sealed Sources waste stream requires a special analysis (SA) because the waste stream ^{60}Co activity concentration exceeds the Nevada National Security Site (NNSS) Waste Acceptance Criteria (WAC) Action Levels (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office [NNSA/NFO] 2013).

2.0 Methods

The SA is performed by adding the inventory of the proposed new or revised waste stream to the current baseline performance assessment (PA) model and determining if there is a reasonable expectation of meeting the U.S. Department of Energy (DOE) Manual DOE M, "Radioactive Waste Management Manual," 435.1-1 Chapter IV, Section P performance objectives (DOE 1999).

2.1 Waste Description

The NPI Sealed Sources waste stream consists of 850 ^{60}Co sealed sources (DRTK 2013). The sources are double sealed in 304L stainless steel capsules.

The NPI Sealed Sources waste stream ^{60}Co inventory is assumed to be lognormally distributed. The geometric mean of the distribution is assumed to be the representative waste stream inventory reported by the generator (DRTK 2013, p. 4) (Table 1).

Table 1. NPI Sealed Sources geometric mean inventory and geometric standard deviation (GSD) (from DRTK 2014a and 2014b)

Nuclide	Geometric Mean Inventory (Bq)	Geometric Standard Deviation
^{60}Co	3.68E+15	14.06

The geometric standard deviation is estimated from the representative and upper limit concentrations on the waste profile sheet (DRTK 2014). The generator reported upper limit activity concentration is assumed to be the 95th percentile of the assumed lognormal distribution. The geometric standard deviation of the waste stream lognormal distribution was calculated as:

$$GSD = e^{\frac{\ln(UL) - \ln(GM)}{1.65}}$$

where

GSD = geometric standard deviation (dimensionless)
UL = upper limit activity concentration, Bq m^{-3}
GM = geometric mean, Bq m^{-3}

The waste stream volume is assumed to be the 80 cubic meters remaining volume reported on the waste profile Section B.6 (DRTK 2014).

2.2 Model Description

The SA is performed using the baseline PA model that was approved at the time the waste profile was submitted for review. This version, referred to as the A5 RWMS v4.115 GoldSim model, uses the radionuclide inventory disposed through fiscal year (FY) 2013 (National Security Technologies, LLC, 2014). The A5 RWMS v4.115 GoldSim model is the result of multiple cycles of internal and external peer review (Shott et al. 1998; Bechtel Nevada [BN] 2006). The model is subject to annual review and updating. Baseline model releases are reviewed and approved by NNSA/NFO prior to use.

The SA is performed by adding the NPI Sealed Sources waste stream radionuclide inventory to the inventory of post-1988 SLB radionuclides disposed through FY 2013. In addition to the SLB inventory, the SA includes the Pit 6, Pit 13, and post-1988 Greater Confinement Disposal borehole inventories. The model is run with a 2.5-meter (8.2-foot) closure cover for SLB disposal units.

The mean and median model results are calculated using 5,000 Latin hypercube samples (LHS). A sample size of 5,000 has been previously shown to provide stable estimates of the mean and 95th percentile results for an earlier version of the PA model (BN 2006). A reasonable expectation of compliance with the performance objectives is assumed if the mean and median are less than the performance objectives. In every case, the mean was greater than the median. Only the mean results are reported in the SA.

For comparison purposes, baseline results are obtained by running the model without the NPI Sealed Sources waste stream inventory.

3.0 Results

The NPI Sealed Sources (DRTK000000056_0) waste stream includes a single radionuclide, ^{60}Co, with a short half-life of 5.27 years (y). The short half-life ensures that the waste stream inventory will decay to negligible levels during institutional control. At the end of a nominal 100-year institutional control period, the total waste stream inventory will decay to 9E8 Bq (0.02 Ci) (Table 2).

Table 2. Activity of NPI Sealed Sources waste stream over time

Date	Elapsed Time (y)	^{60}Co Activity (Ci)	^{60}Co Activity (Bq)
Characterization (11/1/2012)	0	9.95E+04	3.68E+15
Disposal (8/1/2014)	1.8	7.90E+04	2.92E+15
Closure (10/1/2028)	16	1.23E+04	4.54E+14
100 y Post-Closure (10/1/2128)	116	2.39E-02	8.83E+08

3.1 Air Pathway Results

The air pathway annual total effective dose (TED) is evaluated for the resident exposure scenario using 5,000 LHS realizations. The resident exposure scenario estimates the dose to an adult residing in a home at the 100 m (330 ft) site boundary. A complete description of the exposure

scenario can be found in PA documentation (BN 2006). The annual TED is calculated for a period of 1,000 years after closure. The maximum mean and 95th percentile annual TED occur at 1,000 years and are both less than the 0.1 millisievert (mSv) limit (Table 3). Addition of the NPI Sealed Sources waste stream has no significant effect on the resident air pathway results.

Table 3. Maximum air pathway annual TED for a resident at the Area 5 RWMS 100 m (330 ft) site boundary and the waste inventory disposed through FY 2013

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident without DRTK000000056_0 Waste Stream	1,000 y	1.6E-4	5.6E-4
Resident with DRTK000000056_0 Waste Stream	1,000 y	1.6E-4	5.6E-4

3.1.1 Alternative Air Pathway Scenarios

Uncertainty contributed by the selected exposure scenario was evaluated by calculating air pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident farmer scenario, and the open rangeland scenario for a ranch at the nearest NNSS boundary and at Cane Spring. The scenarios and their assumption have been described previously (BN 2006).

The maximum of the mean and 95th percentile are all less than the performance objective for all of the alternative scenarios (Table 4). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the NPI Sealed Sources waste stream has no significant effect on the alternative scenarios air pathway results.

Table 4. Maximum air pathway annual TED for alternative scenarios with the FY 2013 inventory

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2013	1,000 y	8.3E-5	3.0E-4
	FY 2013 with DRTK000000056_0	1,000 y	8.3E-5	3.0E-4
Resident Farmer	FY 2013	1,000 y	4.5E-4	1.6E-3
	FY 2013 with DRTK000000056_0	1,000 y	4.5E-4	1.6E-3
Open Rangeland/Cane Spring	FY 2013	1,000 y	4.8E-9	1.3E-8
	FY 2013 with DRTK000000056_0	1,000 y	4.8E-9	1.3E-8
Open Rangeland/NNSS Boundary	FY 2013	1,000 y	8.1E-8	2.3E-7
	FY 2013 with DRTK000000056_0	1,000 y	8.1E-8	2.3E-7

3.2 All Pathways Results

The all-pathways annual TED is also calculated for the resident exposure scenario. The maximum mean and 95th percentile resident all-pathways annual TEDs are less than the 0.25 mSv limit (Table 5). Addition of the NPI Sealed Sources waste stream has no significant effect on the resident all-pathways annual TED.

Table 5. Maximum all-pathways annual TED for a resident at the Area 5 RWMS 100 m (330 ft) site boundary and the waste inventory disposed through FY 2013

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Resident without DRTK000000056_0 Waste Stream	1,000 y	8.3E-4	2.6E-3
Resident with DRTK000000056_0 Waste Stream	1,000 y	8.3E-4	2.6E-3

There are no significant differences between the resident all-pathways annual TED with and without the NPI Sealed Sources waste stream. Comparison of the means and 95th percentiles indicates they are equivalent throughout the 1,000-year compliance period, except for the 100- to 140-year period (Figure 1). The NPI Sealed Sources waste stream slightly increases the resident all-pathways annual TED 0.5% at 100 years when institutional control begins to fail. The difference decreases rapidly and disappears by 140 years. The addition of the NPI Sealed Sources waste stream has no significant effect on the all-pathways resident annual TED.

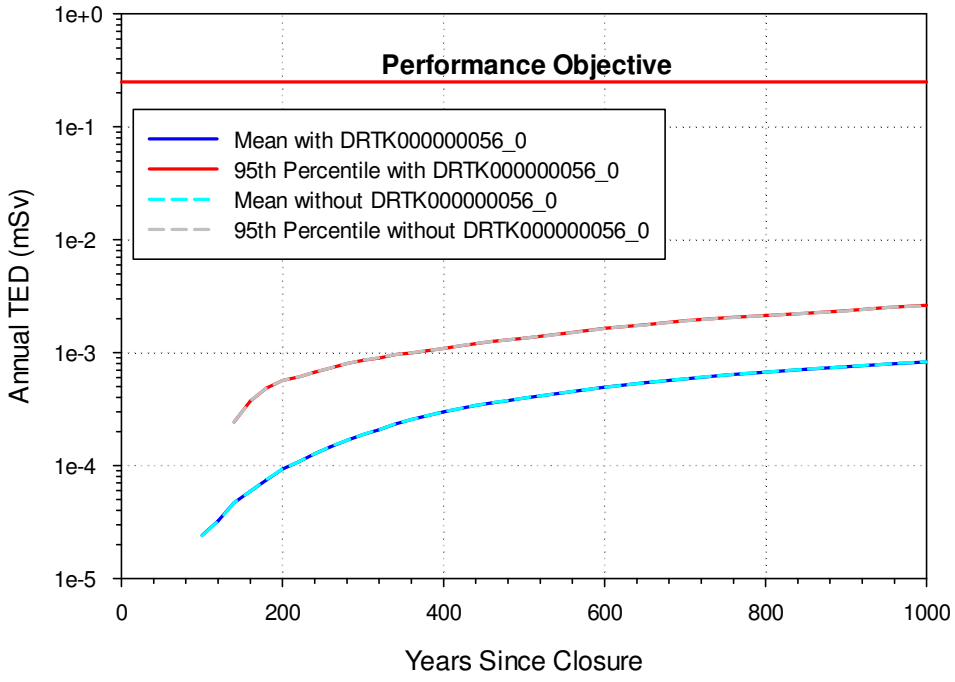

Figure 1. All-pathways annual TED for a resident with and without the DRTK00000056, Rev. 0, waste stream

3.2.1 All Pathways Uncertainty

Alternative Scenarios

Uncertainty contributed by the selected exposure scenario was evaluated by calculating all-pathway annual TED for alternative scenarios. The scenarios evaluated are the transient occupancy scenario, the resident farmer scenario, and the open rangeland scenario for a ranch at the nearest NNSS boundary and at Cane Spring. The scenarios and their assumptions have been described previously (BN 2006).

The mean and 95th percentile annual TEDs are all less than the performance objective for all alternative scenarios (Table 6). Although the exposure scenario is a source of uncertainty, there is a high likelihood of compliance for a range of reasonable scenarios. Addition of the NPI Sealed Sources waste stream has no significant effect on the alternative scenarios all-pathway results.

Table 6. Maximum all-pathway annual TED for alternative scenarios

Scenario	Inventory	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Transient Occupancy	FY 2013	1,000 y	6.5E-3	1.5E-2
	FY 2013 with DRTK000000056_0	1,000 y	6.5E-3	1.5E-2
Resident Farmer	FY 2013	1,000 y	2.3E-2	7.7E-2
	FY 2013 with DRTK000000056_0	1,000 y	2.3E-2	7.7E-2
Open Rangeland/Cane Spring	FY 2013	1,000 y	2.3E-3	8.2E-3
	FY 2013 with DRTK000000056_0	1,000 y	2.3E-3	8.2E-3
Open Rangeland/NNSS Boundary	FY 2013	1,000 y	2.5E-3	9.1E-3
	FY 2013 with DRTK000000056_0	1,000 y	2.5E-3	9.1E-3

3.3 Intruder Results

Intruder results are evaluated for acute intruder scenarios only. NNSA/NFO institutional control policy is to maintain and enforce use restrictions consistent with the Underground Test Area (UGTA) Federal Facilities Agreement and Consent Order closure strategies (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office 2008). The Area 5 RWMS is within the Frenchman Flat UGTA (Corrective Action Unit 98) groundwater use restriction area. The proposed land-use restrictions are assumed to eliminate the possibility of chronic intrusion for 1,000 years.

The acute drilling scenario estimates the TED to a drill crew drilling a water well through a disposal unit. Exposure to contaminated drill cuttings occurs while augering a surface casing for the well. The acute construction scenario estimates the dose to construction workers building a residence on a disposal unit. Construction workers are exposed to waste exhumed from the construction excavation.

The maximum mean and 95th percentile acute intruder TEDs occur at 1,000 years and are less than the 5 mSv limit for both the acute drilling and construction intrusion scenarios (Table 7). Addition of the NPI Sealed Sources waste stream has no significant effect on the acute intruder scenario results.

Table 7. Maximum TED for acute intrusion scenarios at the Area 5 RWMS and the waste inventory disposed through FY 2013

Scenario	Time of Maximum	Mean (mSv)	95th Percentile (mSv)
Drilling Intruder without DRTK000000056_0	1,000 y	1.6E-3	2.9E-3
Drilling Intruder with DRTK000000056_0	1,000 y	1.6E-3	2.9E-3
Construction Intruder without DRTK000000056_0	1,000 y	1.3	2.3
Construction Intruder with DRTK000000056_0	1,000 y	1.3	2.3

3.4 ^{222}Rn Flux Density Results

The ^{222}Rn flux density is averaged over the area of all post-1988 disposal units. The maximum mean and 95th percentile ^{222}Rn flux density occur at 1,000 years and are less than the 0.74 becquerel per square meter per second (Bq m^{-2} s^{-1}) performance objective (Table 8). Addition of the NPI Sealed Sources waste stream has no significant effect on the ^{222}Rn flux density because this waste does not produce ^{222}Rn.

Table 8. Maximum ^{222}Rn flux density at the Area 5 RWMS and the waste inventory disposed through FY 2013

Inventory	Time of Maximum	Mean (Bq m^{-2} s^{-1})	95th Percentile (Bq m^{-2} s^{-1})
FY 2013	1,000 y	0.23	0.50
FY 2013 with DRTK000000056_0 Waste Stream	1,000 y	0.23	0.50

4.0 Conclusions

The results of the SA indicate that there is a reasonable expectation of compliance with all performance objectives with the NPI Sealed Sources (DRTK000000056_0) waste stream disposed in the Area 5 RWMS SLB disposal units. The maximum mean and 95th percentile results are all less than the performance objectives for 1,000 years. Uncertainty analysis indicates that there is a high likelihood of compliance with all performance objectives for a period of 1,000 years after closure with addition of the NPI Sealed Sources waste stream.

The waste stream is recommended for disposal without conditions.

5.0 References

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